SECOND CHANCE V2.0

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Edited by Frank Ernest

SECOND CHANCE, Version 2.0, is a graphics enhancement program for the Apple IIgs written in TML Pascal with ORCA/M.

Thank you for your purchase of SECOND CHANCE.

SECOND CHANCE 2.0 requires an Apple IIgs with 1 megabyte of memory and at least one 3.5-inch disk drive.

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INTRODUCTION

Graphic images that have been converted to a digital form for computer display are, sometimes, of less quality than what we had anticipated. SECOND CHANCE may be able to improve them. Before deleting a graphic image file, give it a SECOND CHANCE. We can not promise that SECOND CHANCE will enhance every graphics image, nor can our programmer (talented as he is!) perform miracles. Successful image enhancement depends mostly on the original quality of the original image and the increasing experience of the user. For these reasons, Raptor, Inc., and the author provide no guarantees or warranties.

SECOND CHANCE was written to operate on an Apple IIgs, 320 mode, gray scale images only. It does not verify that your image is gray scale or in 320 mode. Using the enhancement processes on color images or 640 mode images may produce unpredictable results including "crashing" the system.

ENHANCEMENT SELECTION

Graphics enhancement is more of an art than a science, so don't be discouraged if images are not improved on your first attempts. Be patient. The more you work with SECOND CHANCE, the better your enhancements will turn out. There are only three rules to follow to learn how to use enhancement techniques: Practice, Practice and Practice. If the enhanced image isn't to your liking, restore the original and try a different process, cutoff or threshold. Your image may also need the application of more than one enhancement process or the same one repeated several times. (Note: Some processes may actually make the image worse!)

The descriptions of the processes contain recommendations for their use, but we advise that you experiment to get the best effects.

ABORTING A PROCESS

As any of the processes proceed, the enhanced image will be displayed line by line. Pressing Open-Apple . (period) at any time before the process is complete (cursor changes from the "wait cursor" to the arrow cursor), aborts the process. The original image will be restored and you may then select a menu item. If the process has not been aborted prior to the appearance of the arrow cursor, the new image is automatically saved in memory as the newest enhanced image. The original image is always in memory and is never changed by an enhanced image.

PROCESSING TIMES

The description of the image enhancement processes below include processing time estimates based on tests performed on SCREEN (filetype $C1, AuxType $0000) graphic images. The SCREEN image contains 200 lines. Full-page images, such as those in the Apple Preferred Format and the Paintworks format, will usually contain about 400 lines. If you are working on a full-page image, the estimated processing times will be at least doubled.

Some procedures will ask you to select between enhancing horizontally (across) or vertically (down). The estimated times are for horizontal enhancements. If you are working with a 200 line image, the processing time for vertical enhancement will be approximately one-half the estimated time. If it is a 400 line image, enhancing vertically will take about the same amount of time as horizontal enhancement. The times shown are for an Apple IIgs operating with a standard 2.6 Megahertz clock. For those computers equipped with an Applied Engineering Transwarp GS (TWGS), the processing times will be less. To estimate the processing time using the TWGS, multiply the estimated time by 2.6 and then divide by the clock speed of the TWGS. The use of a math coprocessor card may also improve these processing times.

FILE MENU

The FILE menu provides standard menu items: NEW, OPEN, CLOSE, SAVE, and QUIT; those for printing the image and some new selections. NEW is disabled because SECOND CHANCE will not create an image file. Although NEW performs no function in this program, it is included in order to conform to the Apple Computer, Inc. Human Interface Guidelines, programming guidelines and recommendations.

OPEN and SAVE are functional and SECOND CHANCE will open Screen Format, Apple Preferred Format and Paintworks Format graphics files. When the image is saved, it is saved with exactly the same parameters as the original, other than the enhanced image, of course. SECOND CHANCE does not modify the palette or any other parameter of the original image. When you select CLOSE, the window containing the current graphic image will be closed. If you have performed an enhancement, you will be asked if you want to save the image before closing the window. If you wish to SAVE the enhanced image, be sure to supply a unique filename.

Two selections have been added to the FILE menu: RESTORE ORIGINAL and RESTORE ENHANCEMENT. These two menu items will NOT work with NDAs. If you have made some enhancements and are not satisfied with the results, selecting RESTORE ORIGINAL will restore the original image from memory (not disk). You can then try other processes to improve the image. (Enhancement operations never change the original image so you can always start over.) If you have restored the original image and want to retrieve the most recently enhanced image, select RESTORE ENHANCEMENT. This is not an "undo" option. After every enhancement process, the newest enhanced image is saved in memory. You may alternately select between these two options to compare the enhanced image with the original. The image on the screen is the image the processes will enhance or save, so be sure that your last selection is the image you want for additional processing or saving.

EDIT MENU

The EDIT MENU contains the standard options: UNDO, CUT, COPY, PASTE and CLEAR. None of these selections pertain to image enhancement. This menu and it's options are provided, as recommended by The Apple Human Interface Guidelines, for use by NDAs. An INVERT IMAGE process has been added to this menu and is fully functional except that it will not work with NDAs. INVERT IMAGE reverses the gray levels. That is, white becomes black and black becomes white and so on through the gray scale. This process makes a "negative" of the image on screen. It is provided because some enhancement processes appear to invert the image during their processing. This process will allow you to reverse the inversion without affecting the other enhancements. Also, some enhancement processes may work better on an inverted image than on an original. You can invert an image, perform the process, then invert the image again if necessary.

SMOOTH MENU

As the menu name implies, these processes "smooth" or blur the image. That is, they tend to remove details from the image. While this may seem to be undesirable, there are occasions when smoothing is necessary. Noise appears on images as dots or spots. Smoothing the image will remove noise entirely or reduce it so that the image is improved. Smoothing may also improve the appearance of an enlarged section of a graphic image.

GLOBAL HIST
(Global Histogram)
(Processing time - about 4 minutes)

This process is recommended for images with low contrast. Generally, the less the contrast, the more this process improves the image. (High contrast images will not be improved but may be degraded.) There are limits, of course, Global Histogram can not bring out an image in a totally white or black image. Global Histogram scans the entire image and creates a histogram of the gray levels of the pixels. A probability of occurrence is determined for each gray level and a new gray level is assigned based on that probability. Those occurrences with the lowest probability are assigned black or near-black gray levels. Those with the highest probability are assigned white or near-white gray levels. Then each pixel is assigned the new gray level based on it's original value.

LOCAL HIST
(Local Histogram)
(Processing time - about 2 hours 40 minutes)

This process is recommended for images without a great deal of contrast in limited areas of the image and works on a pixel-by-pixel basis. It works best on those images having large background areas or other large areas of single gray levels. The less contrast, to a point, the more this process will improve the image. High contrast images will not be improved but may be degraded. If there are large areas of a single gray shade, they will not prejudice the histogram toward the high (white) end or low (black) end of the gray scale as in Global Histogram. Local Histogram works in the same way as the Global Histogram except that it determines the histogram from the local "neighborhood" (6 by 6 pixel area) instead of from the entire image. Because it uses only the small part of the image in the neighborhood of the pixel, the results of this process will differ significantly from that of the Global Histogram.

SPECIFIED HIST
(Specified Histogram)
(Processing time - about 4 minutes)

When you select this process, a dialog box will appear on the screen which contains three distribution choices: Binomial, Poisson and Normal (See For the Technically Curious ...) When you select one, you must also supply a parameter value for the distribution you have selected. After clicking on the box for the distribution and supplying the parameter value, click on the "OK" button to start processing. Specified Histogram calculates the Global Histogram, then calculates a new gray scale according to the distribution and values you have provided. Examples of the three selections for different parameters are shown in the charts (See For the Technically Curious ...) located at the end of this manual.

SECOND CHANCE does not check the validity of the number you provide, so you must ensure that it is within the appropriate range. For Binomial, you must provide a value between, but not including "0" and "1". For Poisson, the value of "L" must be greater than "0". (Values of "L" much greater than 15, however, may produce unacceptable results.) For Normal, both the"MEAN" and "STD DEV" values must be greater than "0". (Values of "Mean" much greater than 15, and values of "Std Dev" less than 2 and greater than 10 may also produce unacceptable results.)

NEIGHBORHOOD AVG
(Neighborhood Average)
(Processing time - about 5.5 minutes)

This process helps to remove noise and sharp edges. Noise may be identified as dots of white, black or gray levels appearing randomly in the image. Neighborhood Average begins at the top left pixel, takes the values of the pixels in a 6X6 pixel area surrounding the current pixel, determines the average value of the pixels then reassigns the gray level of the current pixel to this average value.

MEDIAN FILTER
(Processing time - about 5 minutes)

This process also helps to remove noise and sharp edges. This process works pixel-by-pixel as does the Neighborhood Average. Instead of averaging the values of the pixels, the median of the values is taken. The median is that value which is half way between all values and is different from the average. For example, the nine pixels could have values of 0, 1, 1, 1, 1, 2, 2, 15, 15 (sorted in ascending order). The median value is the fifth value, which in this case is 1. Note that this is different from the average value which is 4.

LOW PASS
(Processing time - about 20 minutes)

LOW PASS is also helpful for removing noise and sharp edges from an image. When you select this process, you will be asked to provide a "Cutoff" frequency for the process. Noise and sharp edges are transformed into higher frequencies while gradual gray scale transitions are transformed into lower frequencies. After entering the cutoff frequency, this process removes frequencies above the Cutoff. Those frequencies below the cutoff frequency will not be affected. The higher the cutoff frequency the less effect. (HIGH PASS is found in the SHARPEN menu.)

BAND PASS
(Processing time - about 20 minutes)

If your graphics image contains noise and sharp edges AND gradual transitions that you want to get rid of, use the BAND PASS. When you select this process you will be asked for a Low Cutoff and High Cutoff frequency. Frequencies greater than the High Cutoff and less than the Low Cutoff will be removed. The further the Low and High cutoff frequencies are from each other, the less enhancement will take place. The closer they are to each other, the greater the effect.

BAND STOP
(Processing time - about 20 minutes)

If your graphics image contains noise and sharp edges AND gradual transitions that you want to keep, use the BAND STOP. This process will also ask for a High Cutoff and Low Cutoff frequency. Those frequencies greater than the Low Cutoff and less than the High Cutoff will be removed. The further the Low and High Cutoff frequencies are from each other, the greater the effect. The closer they are to each other, the less the effect. As you have guessed, this process is the opposite of BAND PASS.

ADD TWO
(Processing time - about 2.5 minutes)

Suppose that you have two images of the same scene but something is slightly different in each scene. If you add the two images, the differences between the two scenes are reduced. The result will be those features of the scene which are identical to both images. Since noise is random, adding two different images of the same scene will remove the noise. (This is the primary procedure used by NASA for images sent back by it's space probes.) In order to use this process, there must be two images. To use two different images, open the first image then open the second image without doing any enhancements in between. Select ADD TWO and the first image opened will be redisplayed. As the process continues, the sum of the two images will be displayed. You can also add an original image to an enhanced image. If you want to add an original to an enhanced image, select ADD TWO without loading any other image. If you want to add another image to an enhanced image, Open the new image, then select ADD TWO. This procedure takes the sum of the pixel values of the images and averages them. In some cases, inverting one of the images prior to adding, may improve the enhanced image.

Some cautions:

1. If the process is aborted, a partially enhanced image will remain on the screen. If ADD TWO or SUBTRACT TWO is again selected, this image will be involved in the process.

2. The gray scale of an image may not be standard for any given image. Someone may have altered the gray scale. This will affect adding and subtraction of images.

3. If you open two images, there will be two images in memory. However, the window title will show the name of the last image opened.

4. Watch the name of the file if you save the enhancement. The default name will be the name of the last image opened.

SUBTRACT TWO
(Processing time - about 2.5 minutes)

This procedure is the opposite of ADD TWO. If you have two images of the same scene but something is different in at least one of the images, this procedure will emphasize the differences. (A continuous version of this procedure is used in some security systems to detect motion.) This procedure will also emphasize any noise in the images. In some cases, inverting one of the images prior to subtracting, may improve the enhanced image. (See "Some Cautions", above.)

SHARPEN MENU

As the menu title implies, these processes sharpen and highlight details in the image. They also tend to emphasize noise.

CONTRAST
(Processing time - about 0.5 minutes)

If your graphics image is mostly dark gray or mostly light gray, this process will shift the gray scale of the image. The palette is not changed, just the pixel values. Dark pixels have low value (black is 0), light pixels have a high value (white is 15). When you select this process, you will be asked for a "Threshold" between 0 and 15. Pixels with a value less than the threshold will be made darker by shifting their value down one. Pixels greater than or equal to the threshold will be made lighter by shifting their value up one. A threshold of 0 will make all pixels lighter. A threshold of 15 will make all pixels darker.

RMS:L
(Processing time - about 8 minutes)

If your graphics image lacks sharp edges, this process will sharpen them. When you select this process you will be asked for a "Threshold" value. The process then determines the RMS value of the pixels in an L-shaped region for each pixel in the image. (For an explanation of RMS, see For The Technically Curious...) If the RMS value is less than the threshold value, the current pixel value is not changed. If the RMS value is greater than the threshold value, the current pixel is assigned the new value. The lower the threshold, the greater the effect. The greater the threshold, the less the effect. While the process does sharpen edges, the sharpening does not always occur exactly where it would look the best. Repeated use of this process may produce some surprising or interesting results depending on your artistic senses.

RMS:X
(Processing time - about 8 minutes)

This process also helps to sharpen edges and works in a way similar to the RMS:L selection. However, instead of an L-shaped region, this process uses and X-shaped region. When you select this process you will be asked for a "Threshold" value. If the RMS value is less than threshold value, the current pixel is not changed. If the RMS value is greater than the threshold, the current pixel is assigned the new value. The lower the threshold, the greater the effect. The greater the threshold, the less the effect. Again, the sharpening does not always occur exactly where it would look the best. Repeated use of this process may produce some surprising or interesting results.

HIGH PASS
(Processing time - about 20 minutes)

This process is not recommended to remove noise and sharp edges from an image. Rather, noise and sharp edges will be emphasized. Gradual gray scale transitions will be removed. When you select HIGH PASS, you will be asked to provide a "Cutoff" frequency. Noise and sharp edges are transformed into higher frequencies. Gradual gray scale transitions are transformed into lower frequencies. Those frequencies below the cutoff frequency will be removed. Those frequencies above the cutoff frequency will not be affected. The higher the cutoff frequency, more of an effect will be seen. The lower the cutoff, the less the effect.

POWER FILTER
(Processing time - about 20 minutes)

POWER FILTER can also be for noise removal from a graphic image. While noise can appear as a high frequency, noise can also be a range of frequencies. High frequency noise is seen on an image as spots or dots of single white, black or gray level. When it appears as a range of frequencies, it is called "white noise". (The term "white noise" has nothing to do with the color or gray scale level of the noise.) It is seen on an image as dots at different gray levels. When white noise occurs, it is usually of low power. POWER FILTER will remove these low power frequencies. When you select this process, you will be asked for a "Threshold." Acceptable values are between 0 and 100. Any frequency whose current power is less than the threshold is set to zero. A threshold of 0 will have no effect on the image and a threshold of 100 will remove all frequencies. The vast majority of graphic images do not contain white noise but consist of many low power frequencies. Use of this process may degrade your image.

ILLUMINATION *
(Processing time - about 9 hours)

Every graphic image has two characteristics, illumination and reflectance. Illumination is the amount of light falling on the objects in the image. Reflectance is the amount of light reflected by those objects. (See For The Technically Curious...) These two characteristics of graphic images are used by Computer Aided Design (CAD) programs to create pictures by a technique called "ray tracing". CAD and ray tracing are beyond the capability of this program, however, images can be improved by making use of these characteristics. This process removes the reflectance components from the image and emphasizes the illumination components. Illumination tends to consist of low frequency components. This process removes the high frequency components of reflectance in a manner similar to LOW PASS filter. When you select this process, you will be asked for a

"Cutoff" frequency. Frequencies below the cutoff will not be affected. Those frequencies above the cutoff will be removed. The higher the cutoff, the less the effect. The lower the cutoff, the more the effect.

REFLECTANCE *
(Processing time - about 9 hours)

Reflectance consists of high frequency components and this process removes the low frequency components of illumination in a way similar to the HIGH PASS filter. (See For The Technically Curious...) When you select this process, you will be asked to provide a "Cutoff" frequency. Frequencies above the cutoff will not be affected. Those frequencies below cutoff will be removed. The higher the cutoff, the greater the effect. The lower the cutoff, the less the effect.

RESTORE MENU

The two processes in this menu, DECONVOLVE and INVERSE FILTER, will restore an image that was smeared by movement of either the camera or the subject during the exposure. The processes seem to work well with artificially smeared images created for testing purposes. If you have the capability, scan or digitize the image as large as possible. The more information contained in the image and the greater the contrast in the image, the better these processes will work. When you select either process, you will be asked to set the "distance" of the smear. That is, approximately how many pixels the smear appears to cover. If the camera moved, most of the image will be smeared, but do not select the entire image. Select only the pixel distance smeared. For example, let us assume that the image is that of the face of a person. In an unsmeared image, the pupil of the eye would be 5 pixels wide. In the smeared image, the pupil is 10 pixels. The smear distance is 5 pixels. That is, the smeared size minus the normal size.

DECONVOLVE
(Processing time - about 1 hour)

A smeared picture can be thought of as the original, unsmeared image combined with a "response function". Deconvolve is the reversal of this process. After selecting this process, a dialog box will appear which asks for the "Distance" as described above. After specifying the distance, you will be asked to set the "Amplitude" of the "response function". This process is very sensitive. A small error in setting the values can trash the image. If the process does not seem to work properly, try changing the "distance" first as Deconvolve is more sensitive to distance than to amplitude. This process is also extremely sensitive to noise in the image. It may be a good idea to use one of the smoothing processes before using Deconvolve.

INVERSE FILTER
(Processing time - Varies with "Distance")

For a distance of 5 - about 6 hours.
For a distance of 10 - about 1.5 hours.
For a distance of 20 - about 30 minutes.
For a distance of 30 - about 14 minutes.

The INVERSE FILTER performs much the same function as the Deconvolve process. It is much less sensitive to noise than the Deconvolve process. But it is sensitive to the "distance" value. Selecting the wrong distance can produce unacceptable results. After selecting this process, a dialog box will ask for the "distance" as described above. After setting the distance, another dialog box will ask you to set the "Average". This is your estimate of the average gray level of the normal, unsmeared image. Remember that black is 0 and that white is 15. This process is not very sensitive to the average value, so if your image comes out very dark, increase the average value. A good average value to start with for the Apple IIgs is 8.

PHOTOGRAPHS

The following photographs are provided as an aid to guide you in selecting the enhancement process for your image. The actual enhancement process used is dependent on your original image and the effect or effects you wish to create.

PHOTO 1: Original. This photo was intentionally under exposed to create contrast.

PHOTO 2: GLOBAL HISTOGRAM applied to PHOTO 1.

PHOTO 3: LOCAL HISTOGRAM applied to PHOTO 1.

PHOTO 4: SPECIFIED HISTOGRAM applied to PHOTO 1 using Poisson with L = 5.

PHOTO 5: ORIGINAL. This photo was made from a section of PHOTO 1 then doubled in size using Paintworks Gold.

PHOTO 6: NEIGHBORHOOD AVERAGE applied to PHOTO 1. There is a slight blurring of the PHOTO.

PHOTO 7. MEDIAN FILTER applied to PHOTO 1. The blurring in this PHOTO is less than that in PHOTO 6.

PHOTO 8. MEDIAN FILTER applied to PHOTO 7. The blurring is slightly increased yet still less than that of PHOTO 6.

PHOTO 9. LOW PASS FILTER applied horizontally to PHOTO 5 with the Cutoff set to 500. The gray bands seen at the left and right of the main PHOTO are inherent in this process.

PHOTO 10. LOW PASS FILTER applied vertically to PHOTO 5 with the cutoff set to 250. The lower contrast of this PHOTO, compared to PHOTO 9, is inherent in vertical processing.

PHOTO 11. ORIGINAL.

PHOTO 12. BAND STOP applied horizontally to PHOTO 11 with Low Cutoff set to 240 and High Cutoff set to 260.

PHOTO 13. BAND PASS applied horizontally to PHOTO 11 with the Low Cutoff set to 20 and the High Cutoff set to 500. There is a similarity with this PHOTO and that of PHOTO 17 due to the cutoff of some of the high frequencies.

PHOTO 14. BAND PASS applied vertically to PHOTO 11 with the Low Cutoff set to 20 and the High Cutoff set to 250. There is a similarity with this PHOTO and that of PHOTO 18, again, due to the cutoff of some of the high frequencies.

PHOTO 15. RMS:L applied to PHOTO 11 with the cutoff set to 2. The black dots are the result of a slight edge enhancement.

PHOTO 16. RMS:X applied to PHOTO 11 with the cutoff set to 2. The black dots and lines are the result of a slightly greater edge enhancement.

PHOTO 17. HIGH PASS FILTER applied horizontally to PHOTO 11 with the Cutoff set to 10. The PHOTO appears to be a "negative" of the original PHOTO because the high frequencies, i.e., the edges and noise, are emphasized by the removal of the low frequencies.

PHOTO 18. HIGH PASS FILTER applied vertically to PHOTO 11 with the Cutoff set to 10. (See PHOTO 17.)

PHOTO 19. POWER FILTER applied horizontally to PHOTO 11 with the Cutoff set to 1. In this case, the image was smeared and made worse by the process. This indicates that the image is composed off many low power components.

PHOTO 20. POWER FILTER applied vertically to PHOTO 11 with the Cutoff set to 1. (See PHOTO 19.)

PHOTO 21. INVERSE FILTER applied to the same PHOTO. The upper portion is the result of the "unsmearing" process of the INVERSE FILTER. The lower portion is the original smeared image. This image was artificially created to demonstrate the effectiveness of this process. The grey line in the upper portion was smeared to the right by 10 pixels. An actual smeared image was not available.

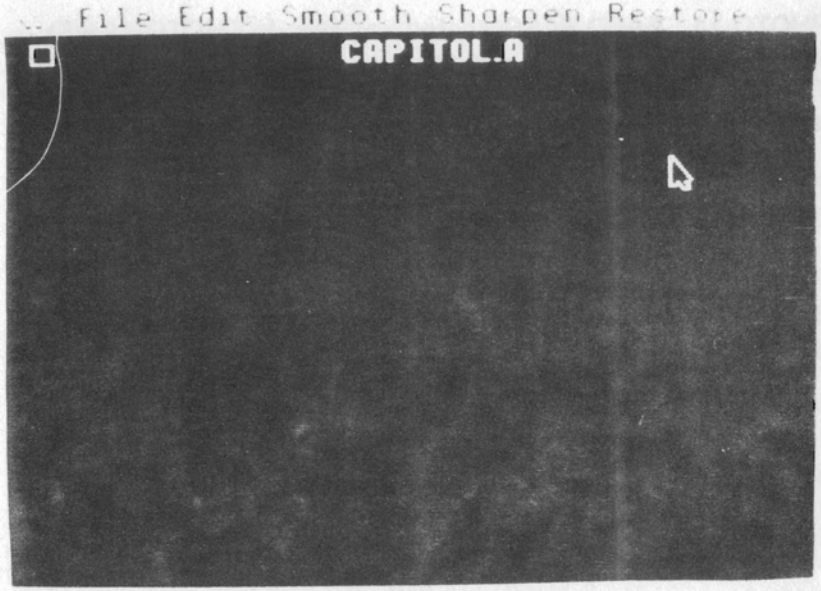


PHOTO 1

PHOTO 2

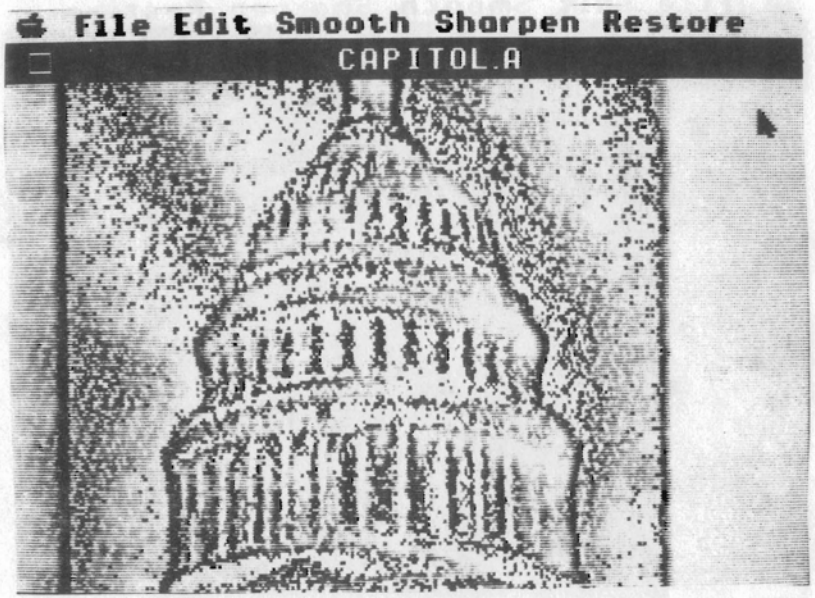


PHOTO 3

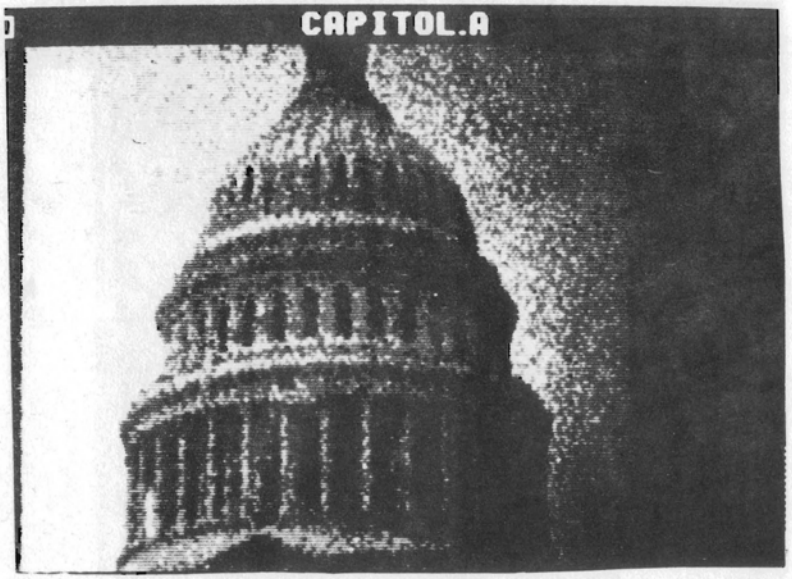


PHOTO 4

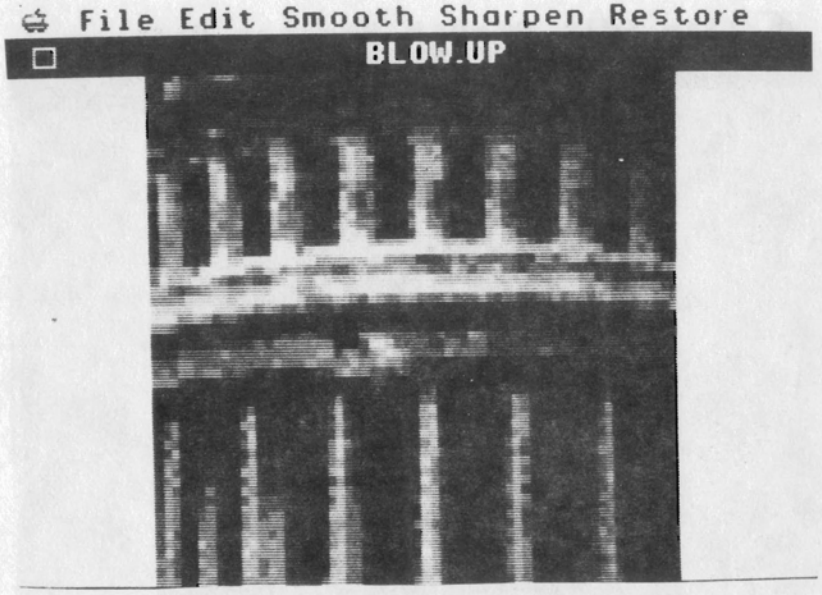


PHOTO 5

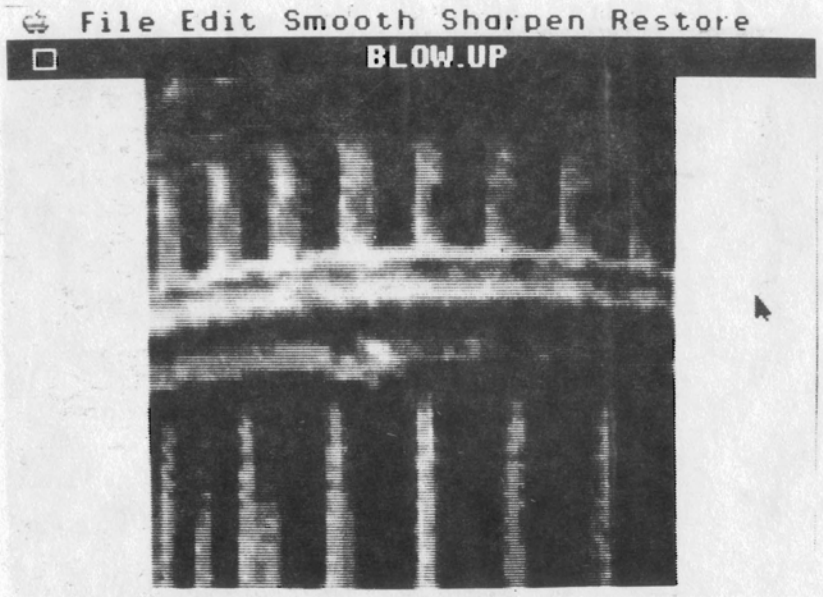


PHOTO 6

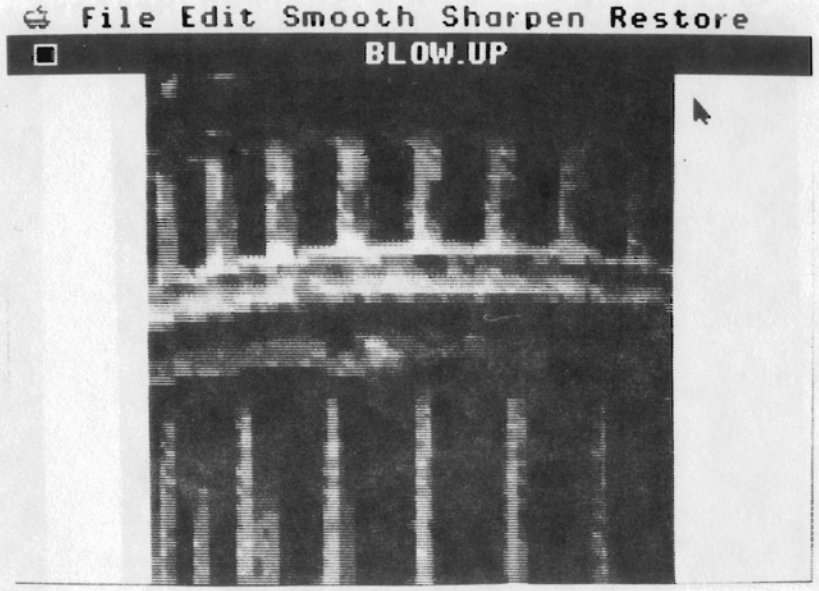


PHOTO 7

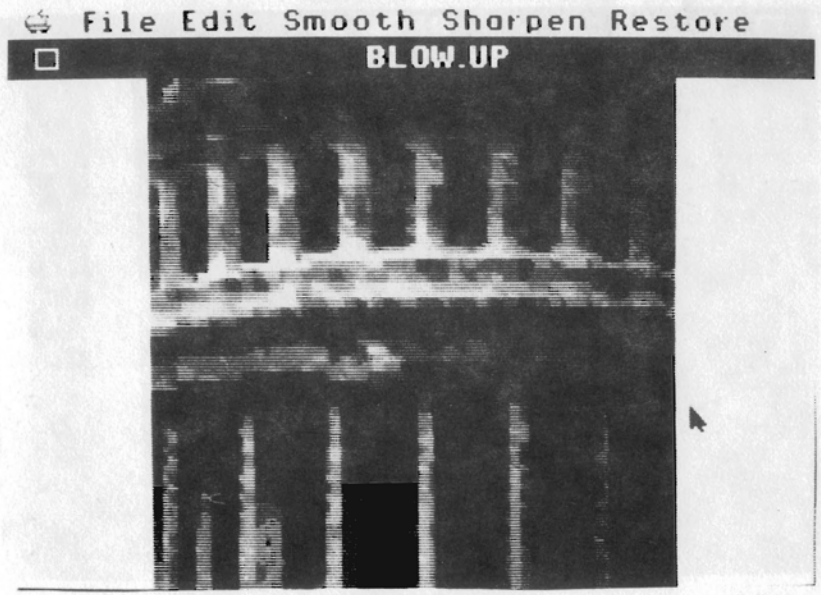


PHOTO 8

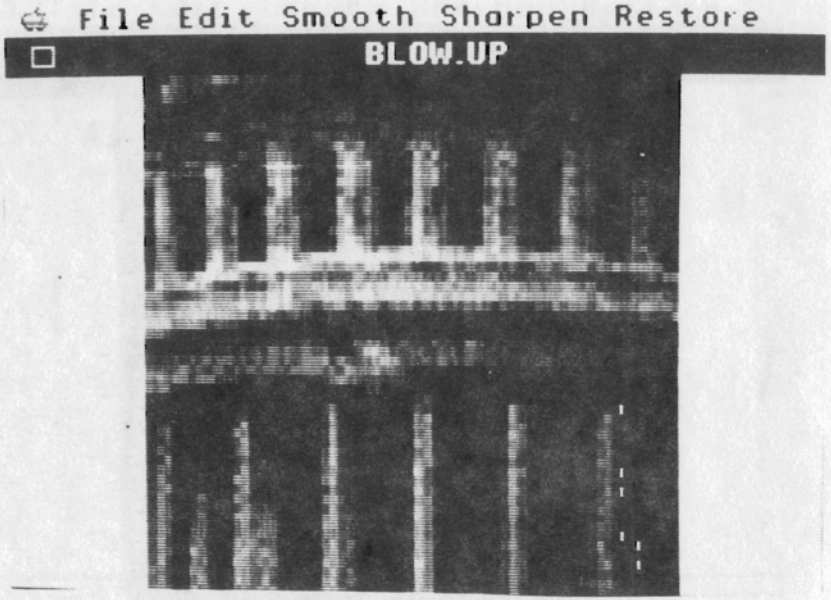


PHOTO 9

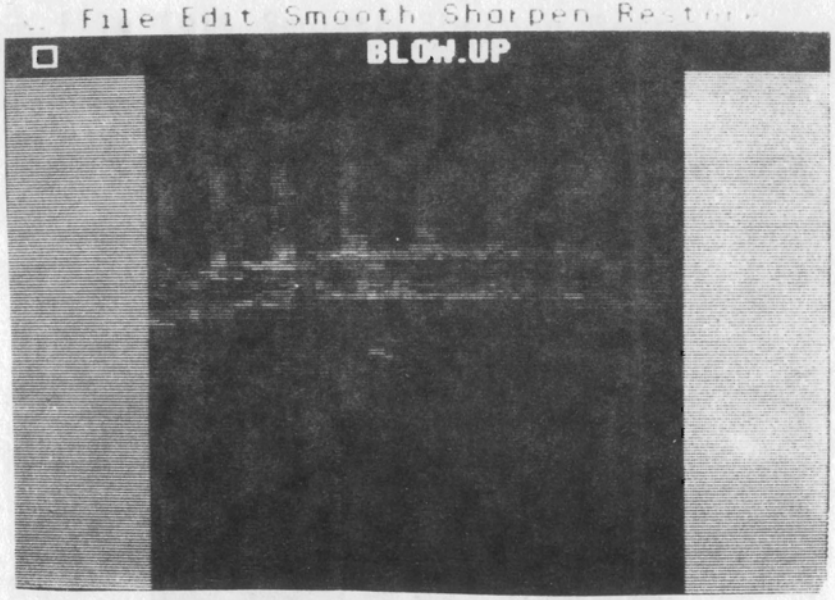


PHOTO 10

PHOTO 11

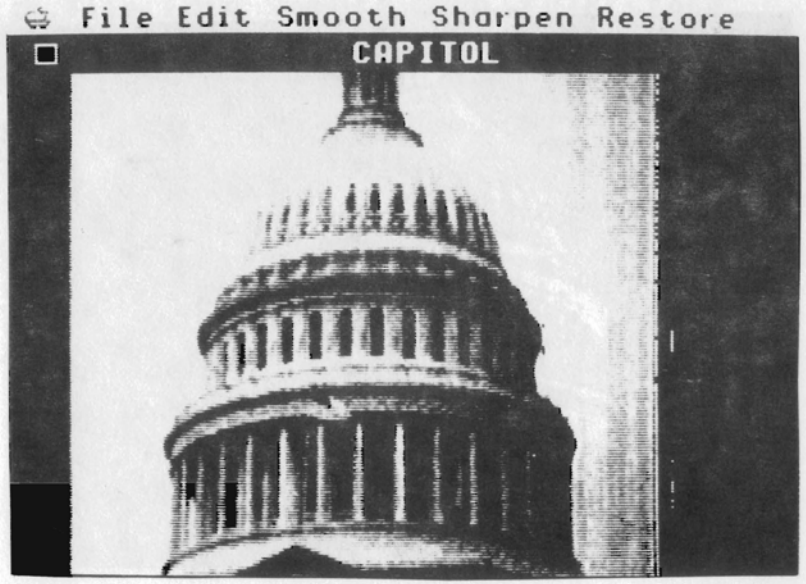


PHOTO 12

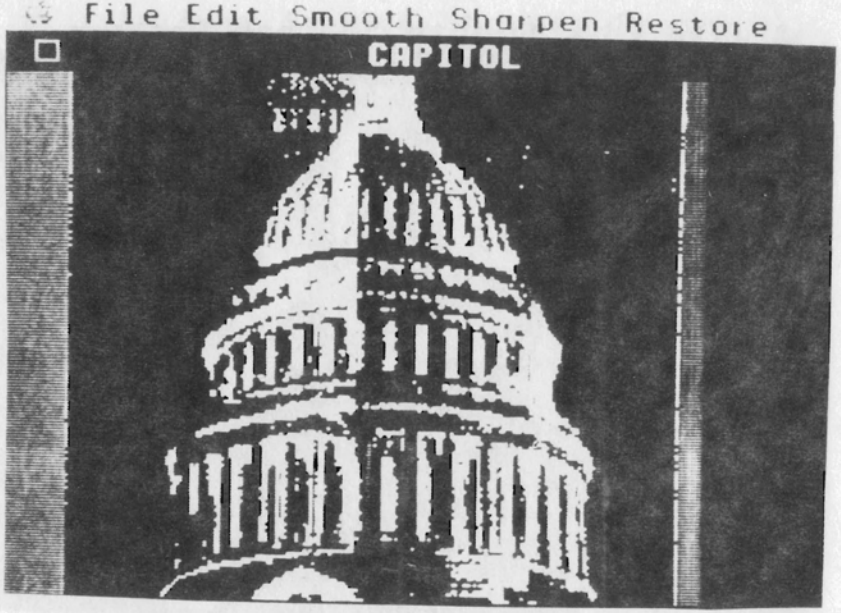


PHOTO 13

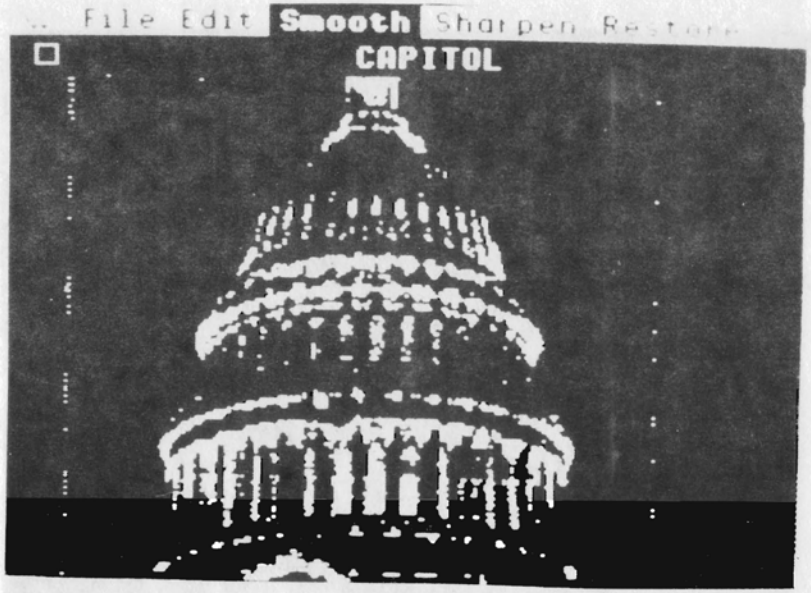


PHOTO 14

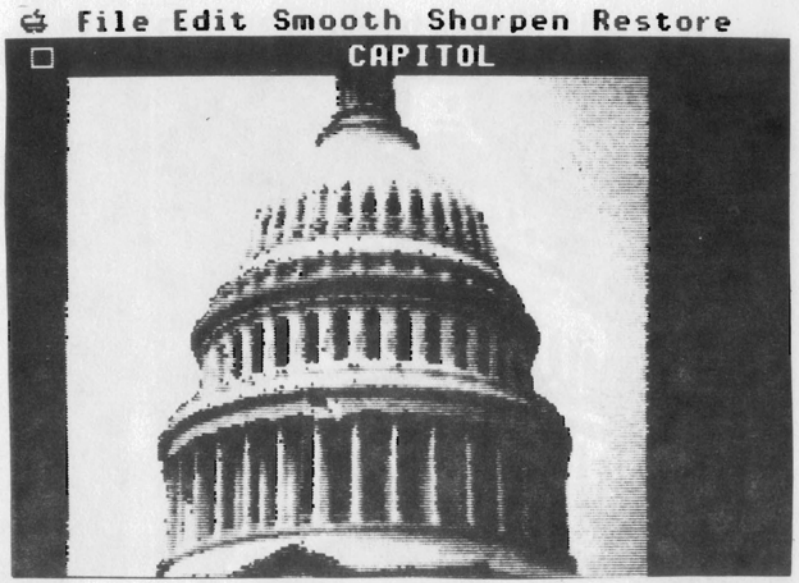


PHOTO 15

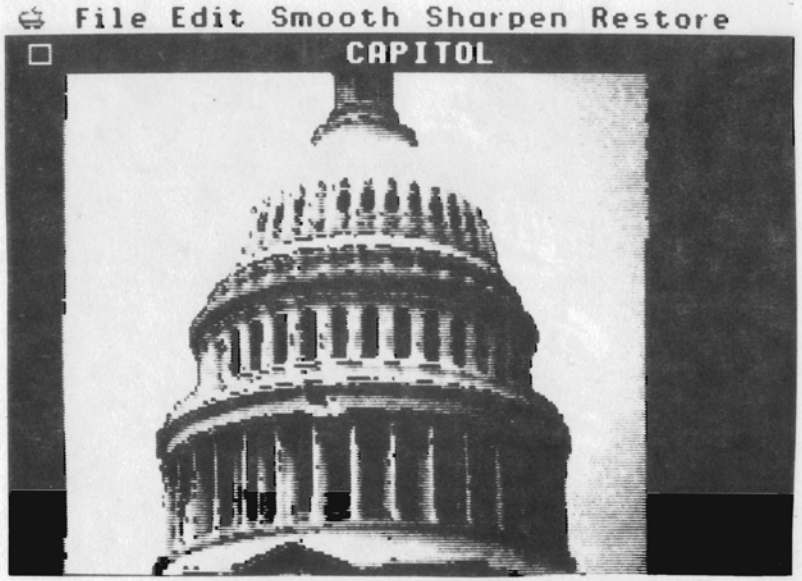


PHOTO 16

PHOTO 17

PHOTO 18

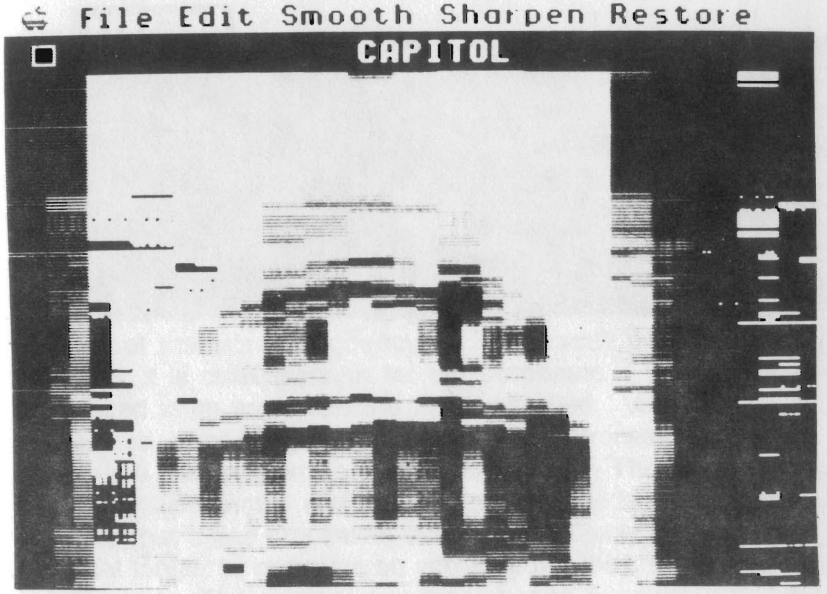


PHOTO 19

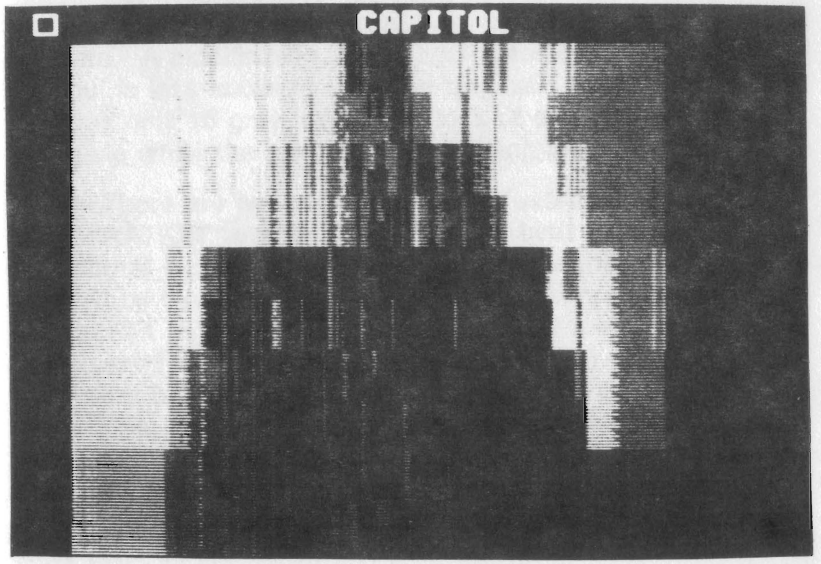


PHOTO 20

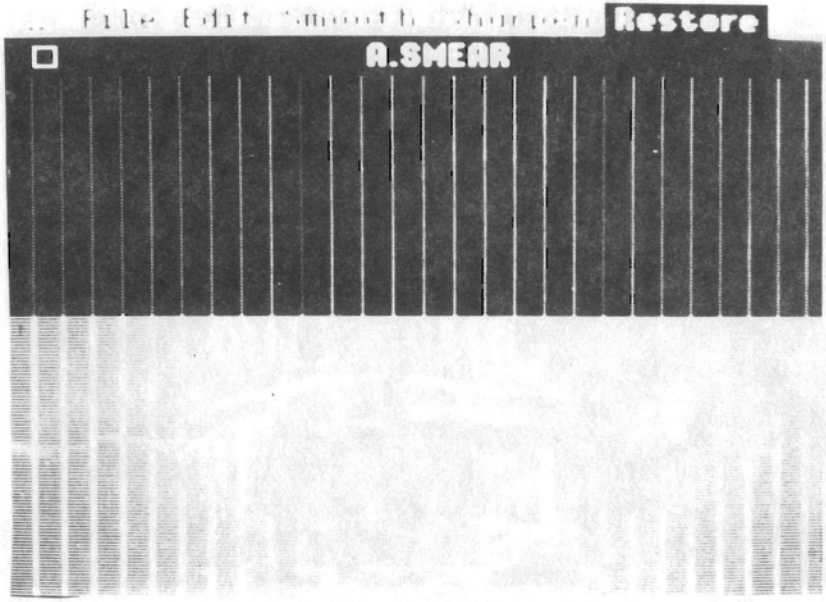


PHOTO 21

FOR THE TECHNICALLY CURIOUS ...

FAST FOURIER TRANSFORM

The Fast Fourier Transform (FFT) is used in many of the enhancement processes. The FFT converts an array of time domain data into a range of frequencies. Since graphic images are not in the time domain but are in a length domain, the use of the word "frequency" is not exactly correct. However, it is close enough for our purposes. Pixel values are placed in an array and the FFT is applied. Various procedures, depending on the enhancement process you select, are then applied to these frequencies. The Inverse FFT is then performed and the enhanced image is shown. You will note that those processes using the FFT may take somehat longer to complete so you may not think that the FFT is very fast. The original computer-based Fourier Transform could take as much as a week of processing time to transform just one screen line of 320 pixels. Comparatively, the FFT is very fast.

SECOND CHANCE uses two different types of FFT. The original algorithm takes a great deal of time and is very accurate. A modification, made by Raptor, Inc., takes less time but is less accurate than the original. Since the Apple IIGS has only 16 gray levels, the loss of accuracy is negligible while the saving in processing time is substantial.

There are two processes which use the original FFT: "ILLUMINATION" and "REFLECTANCE" both of which also use natural logarithms. In order to provide the accuracy required by these processes, it was necessary to retain the original FFT algorithm. If you select one of these processes, be prepared to wait (they take a LOT of time). Turn your monitor off but leave the computer on. Then read a book, talk to your spouse, go to a movie, or visit friends or relatives. To remind you that these processes are time consuming, they are marked in the menu with an asterisk (*). For both processes, the natural logarithm is taken of every pixel before the FFT is performed, the FFT and the

natural logarithm separate the illumination components from the reflectance components. Frequencies above or below the Cutoff, as appropriate, are removed. The Inverse FFT and then the inverse logarithm are performed to extract the pixel values.

RMS (ROOT-MEAN-SQUARE)

The processes RMS:L and RMS:X take the RMS value in the neighborhood of the current pixel. An RMS value is obtained by using four pixel values which we shall call P1, P2, P3 and P4. First P1 is subtracted from P2 to get R1 and P3 is subtracted from P4 to get R2. R1 and R2 are squared to get S1 and S2. Then S1 and S2 are added together and divided by 2 to get M1, the mean. Finally the square root of M1 is taken to get the RMS value. The procedure squares, finds the mean then takes the root. The term "root-mean-square" derived it's name from the reverse of the mathematical steps.

EXAMPLES OF DISTRIBUTION SELECTION

All gray scale levels are whole numbers and range from 0 to 15. The number 0 identifies black and the number 15, white. Decimal numbers are not allowed. To determine what the new gray scale shade would be, refer to the appropriate chart and find the Old Gray Scale at the left of the chart along the "Y-axis". Move across to the graph of the function, then down to the "X-axis". The number to the left will be the New Gray Scale level. For example, select Poisson and set the "L" value to 5. If the global histogram determines a gray scale level of 6, all pixels which would be assigned a level of 6 will be changed to a gray scale level of 3 and the gray scale will be shifted toward black, making the enhanced image darker. Changing the "L" value to 10 (Poisson selected) will assign a gray scale value of 8 rather than 3. This shifts the enhanced image toward white.

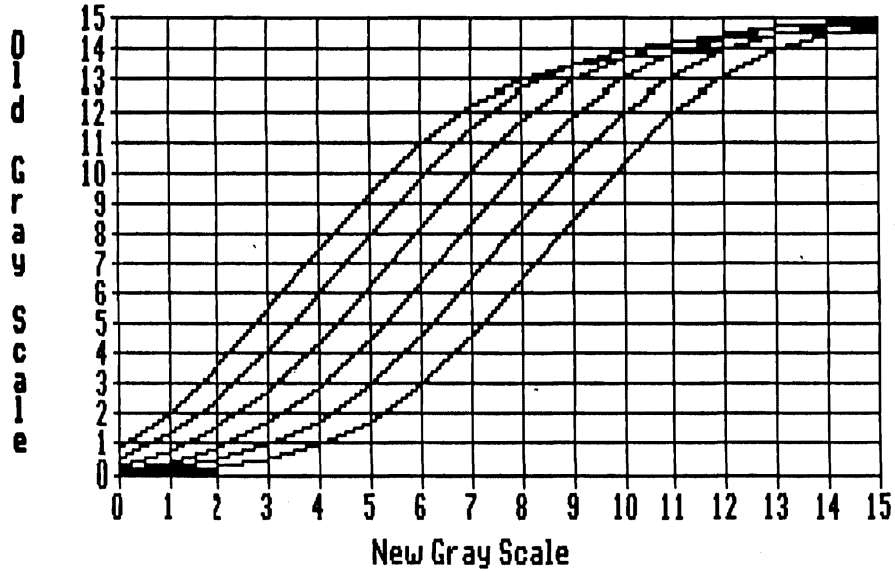
Probability Distributions

A discussion of probability distributions is beyond the scope of this manual. We refer you to text books on probability and statistics for further information. However, for those already familiar with probability and are a bit curious we offer the following information. The Binomial Distribution coefficient "n" in n! / t! (n - t)! is taken as a constant value of 30. The coefficient "t" varies from 0 to 15 to correspond to the values a pixel can assume. Since p + q = 1 by definition, it is only necessary that one of these parameters be given and we have chosen "p" to be provided by the user. For the Poisson Distribution, the value of "t" in t! varies from 0 to 15 as it did for the Binomial Distribution. The value of lambda (L) is provided by the user. For the Normal distribution, you provide both the MEAN and the Standard Deviation (STD DEV). These two parameters completely define the Normal Distribution.

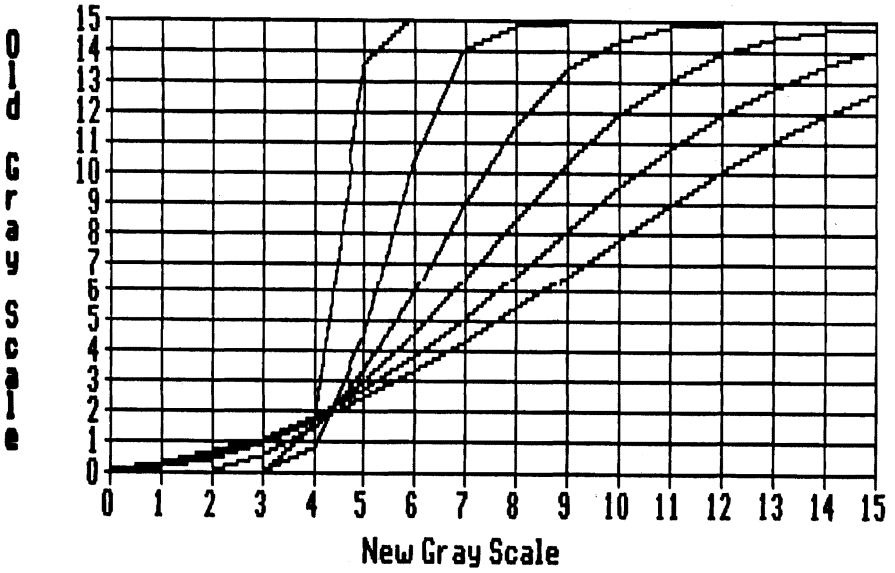
GRAPHS

The following graphs are provided as an aid to guide you in selecting the appropriate enhancement for your image. The enhancement process does not tell you the pixel values. Nor can you set the pixel values in any way other than by selecting the distribution type and setting it's parameter(s).

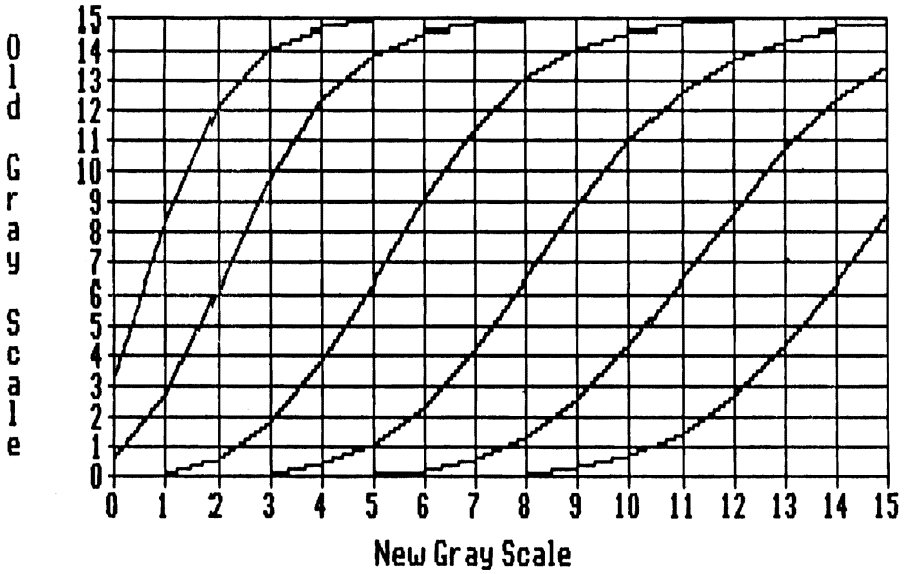
Normal Distribution
Std Dev = 3: Mean = 4, 5, 6, 7, 8, 9



Normal Distribution
Mean = 7.5: Std Dev = 0.5, 1, 2, 3, 4, 5



Binomial Distribution
N = 30: p = 0.05, 0.10, 0.20, 0.30, 0.40, 0.50



Poisson Distribution
Lambda = 5, 6, 7, 8, 9, 10